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Contribution from the Bureau of Entomology, L. O. Howard, Chief.

HOUSE FLIES.

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INTRODUCTION.

There are several species of flies which are commonly found in houses, although but one of these should properly be called the house fly. This fly, *Musca domestica* L. (fig. 1), which is found in

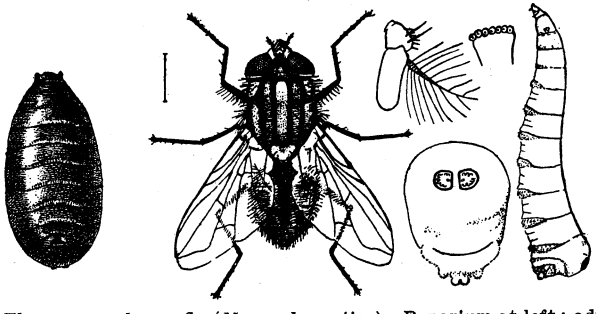

FIG. 1.—The common house fly (*Musca domestica*) : Puparium at left ; adult next ; larva and enlarged parts at right. All enlarged. (Author's illustration.)

nearly all parts of the world, is a medium-sized grayish fly, with its mouth parts spread out at the tip for sucking up liquid substances. On account of the conformation of its mouth parts, the house fly can not bite, yet no impression is stronger in the minds of most people than that this insect does occasionally bite. This impression is due

NOTE.—This bulletin supersedes Farmers' Bulletin No. 459. It will be of interest wherever breeding places for flies are found.

to the frequent occurrence in houses of another fly (*Stomoxys calcitrans* L.) (fig. 2), which is called the stable fly, and which, while closely resembling the house fly (so closely, in fact, as to deceive anyone but an entomologist), differs from it in the important particular

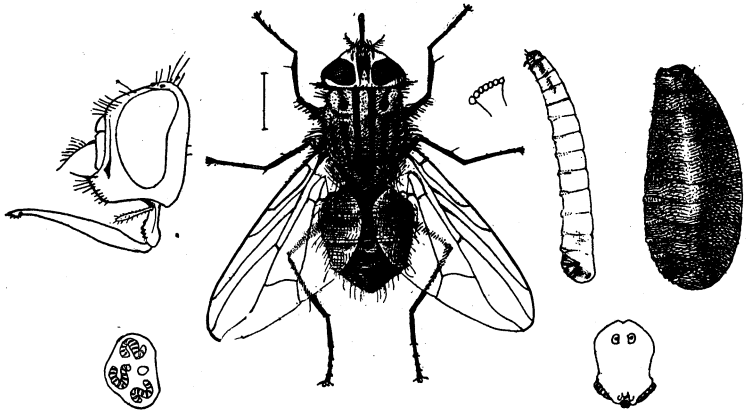

FIG. 2.—The stable fly or biting house fly (*Stomoxys calcitrans*): Adult, larva, puparium, and details. All enlarged. (Author's illustration.)

that its mouth parts are formed for piercing the skin. It is perhaps second in point of abundance to the house fly in most portions of the Northeastern States. It breeds in horse manure, cow manure, and in warm, decaying vegetation, like old straw and grass heaps.

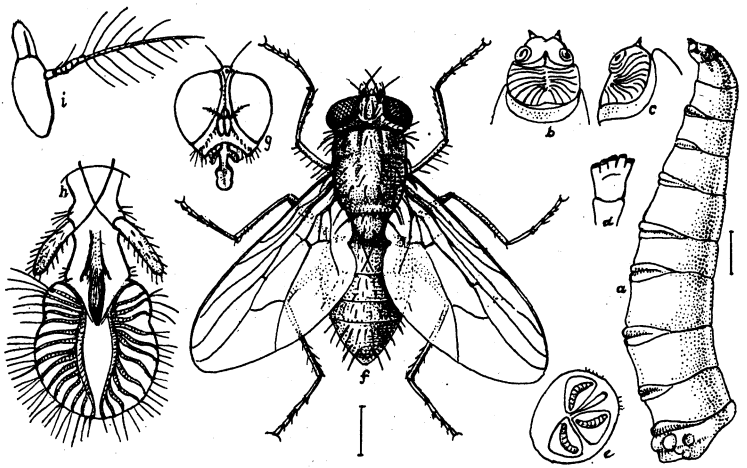

FIG. 3.—A stable fly (*Muscina stabulans*): Adult, larva, and details. All enlarged. (Author's illustration.)

A third species, commonly called the cluster fly (*Pollenia rudis* Fab.), is a very frequent visitant of houses, particularly in the spring and fall. This fly is somewhat larger than the house fly, with a smooth, dark-colored abdomen and a sprinkling of yellowish hairs.

It is not so active as the house fly and, particularly in the fall, is very sluggish. At such times it may be picked up readily, and is very subject to the attacks of a fungous disease which causes it to die upon the window panes, surrounded by a whitish efflorescence. Occasionally this fly occurs in houses in such numbers as to cause great annoyance, but such occurrences are comparatively rare. It is said in its earlier stages to be parasitic on certain angleworms.

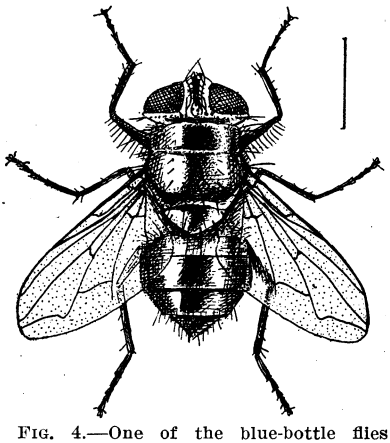

FIG. 4.—One of the blue-bottle flies (*Phormia terraenovae*): Adult, enlarged. (Author's illustration.)

A fourth species is another stable fly, known as *Muscina stabulans* Fall. (fig. 3), a form which almost exactly resembles the house fly in general appearance, and which does not bite, as does the biting stable fly. It breeds in decaying vegetable matter and in excrement.

Several species of metallic greenish or bluish flies are also occasionally found in houses, the most abundant of which is the so-called bluebottle fly (*Calliphora erythrocephala* Meig.). This insect is also called the blow fly, or meat fly, and breeds in decaying animal material. A smaller species, which may be called the small bluebottle fly, is *Phormia terraenovae* Desv. (fig. 4), and a third, which is green or blue in color and a trifle smaller than the large bluebottle fly, is *Lucilia caesar* L. (fig. 5).

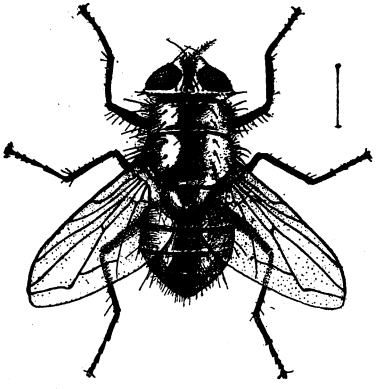

FIG. 5.—The green-bottle fly (*Lucilia caesar*): Adult, enlarged. (Author's illustration.)

There is still another species, smaller than any of those so far mentioned, which is known to entomologists as (*Homalomyia*) *Fannia canicularis* L., sometimes called the small house fly. A related species, *F. brevis* Rond., is shown in figure 6. *F. canicularis* is distinguished from the ordinary house fly by its paler and more pointed body and conical shape. The male, which is much commoner than the female, has large pale patches at the base of the abdomen, which are translucent when the fly is seen on the window pane. It is this species that is largely responsible for the prevalent idea that flies grow after gaining wings. Most people think that these little fannias are the young of the larger flies, which,

of course, is distinctly not the case. They breed in decaying vegetable material, in excreta of animals, and in dead insects.

Still another fly—and this one is still smaller—is a jet-black species known as the window fly (*Scenopinus fenestralis* L.), which

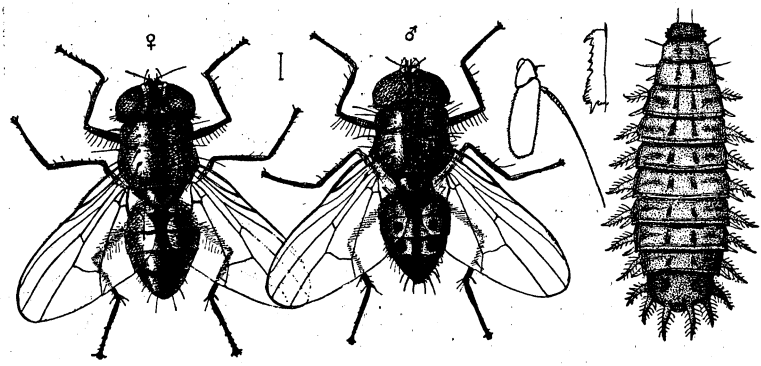

FIG. 6.—The little house fly (*Homalomyia brevis*) : Female at left; male next, with enlarged antenna; larva at right. All enlarged. (Author's illustration.)

in fact has become more abundant of later years. Its larva is a white, very slender, almost threadlike creature and is found in cracks of the floor in buildings, where it feeds on other small insects.

In the autumn, when fruit appears on the sideboard, many specimens of a small fruit fly (*Drosophila ampelophila* Loew) (fig. 7) make their appearance, attracted by the odor of overripe fruit.

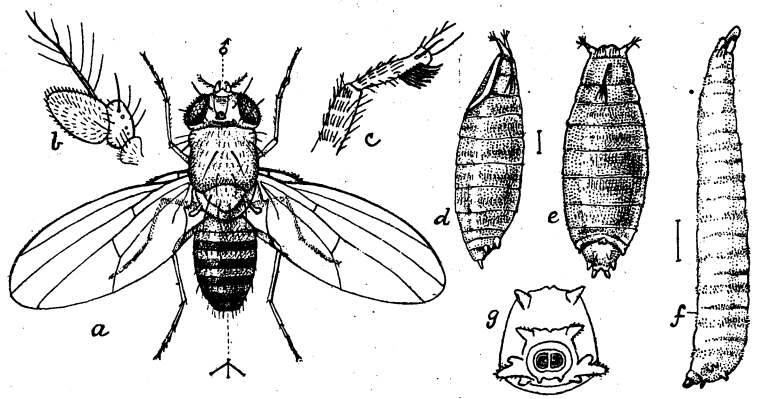

FIG. 7.—The fruit fly (*Drosophila ampelophila*) : *a*, Adult; *b*, antenna of same; *c*, base of tibia and first tarsal joint of same; *d*, puparium, side view; *e*, puparium from above; *f*, full-grown larva; *g*, anal spiracles of same. All enlarged. (Author's illustration.)

A small slender fly is not infrequently seen in houses, especially upon windowpanes. This is *Sepsis violacea* Meig., shown enlarged in figure 8.

All of these species, however, are greatly dwarfed in numbers by the common house fly. In 1900 the senior author made collections

of the flies in dining rooms in different parts of the country, and out of a total of 23,087 flies 22,808 were *Musca domestica*—that is, 98.8 per cent of the whole number captured. The remainder, consisting of 1.2 per cent of the whole, comprised various species, including those mentioned above.

LIFE HISTORY OF THE TRUE HOUSE FLY.

Musca domestica commonly lays its eggs (figs. 9, 10) upon horse manure. This substance seems to be its favorite larval food. It will also breed in human excrement, and from this habit it becomes very

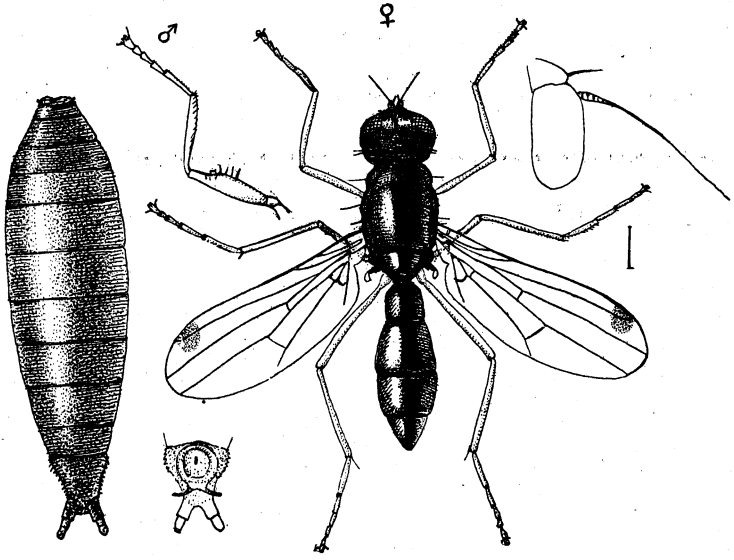

FIG. 8.—The dung fly (*Sepsis violacea*) : Adult, puparium, and details. All enlarged. (Author's illustration.)

dangerous to the health of human beings, carrying as it does the germs of intestinal diseases, such as typhoid fever and cholera, from the excreta to food supplies. It has also been found to breed freely in hog manure and to some extent in cow and chicken manure. Indeed, it will lay its eggs on a great variety of decaying vegetable and animal material, but of the flies that infest dwelling houses, both in cities and on farms, a vast proportion come from horse manure.

It often happens, however, that this fly is very abundant in localities where there is little or no horse manure, and in such cases it will be found breeding in other manure or in slops or fermenting vegetable material, such as spent hops, bran, ensilage, or rotting potatoes. Accumulations of organic material on the dumping grounds of towns and cities often produce flies in great numbers.

The number of eggs laid by an individual fly at one time is undoubtedly large, probably averaging about 120, and as a single female will lay at least two and possibly four such batches, the enormous numbers in which the insects occur is thus plainly accounted for, especially when the abundance and universal occurrence of appropriate larval food is considered. The eggs are deposited below the surface in the cracks and interstices of the manure, several females usually depositing in one spot, so that the eggs are commonly found in large clusters in selected places near the top of the pile,

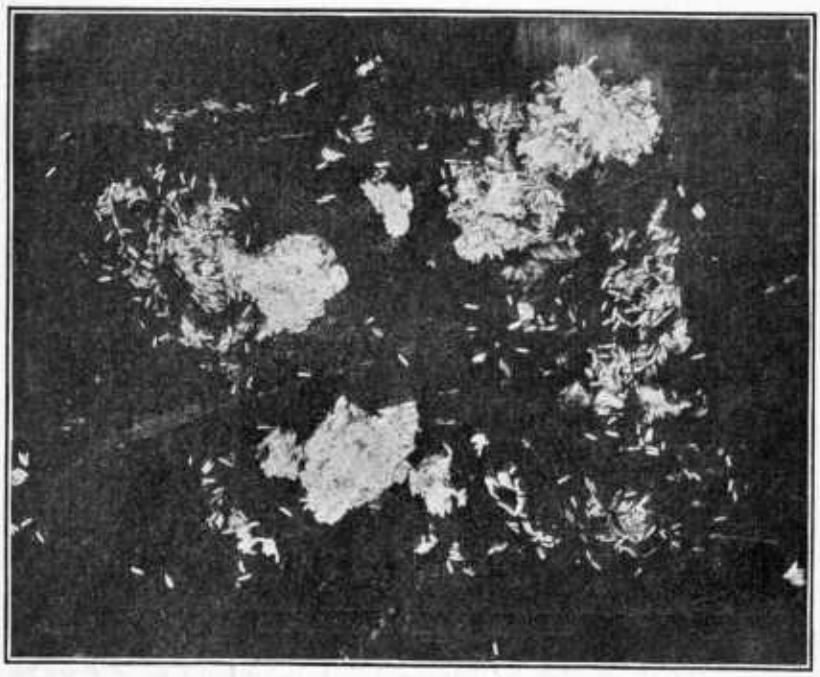

FIG. 9.—Eggs of the house fly. About natural size. (From Newstead.)

where a high degree of heat is maintained by the fermentation below. The eggs usually hatch in less than 24 hours. Under the most favorable conditions of temperature and moisture the egg state may last hardly more than eight hours. The maggots which issue from the eggs are very small and transparent. They grow rapidly and in the course of their development molt twice. There are thus three distinct larval stages, the duration of which is about as follows: (1) From hatching of the larva to first molt, one day; (2) first to second molt, one day; (3) second molt to pupation, two to three days, thus making the total length of the larval stage four to five days. This period may be greatly prolonged by low temperature or by dryness or scarcity of the larval food. As the larvæ (fig. 11)

attain full size they gradually assume a creamy white color. Just before pupation they become very restless and migrate from their feeding ground in search of a favorable place in which to pass the pupal stage. They will often congregate at the edges of manure piles near the ground or burrow into the soil beneath, or they may crawl considerable distances away from the pile to pupate in the ground or in loose material under the edges of stones, boards, etc.

The pupæ (fig. 12), or "sleepers," are more or less barrel shaped and dark brown in color. In midsummer this stage lasts from three to ten days, four to five days being the usual duration. The pupal stage is easily affected by temperature changes and may be prolonged

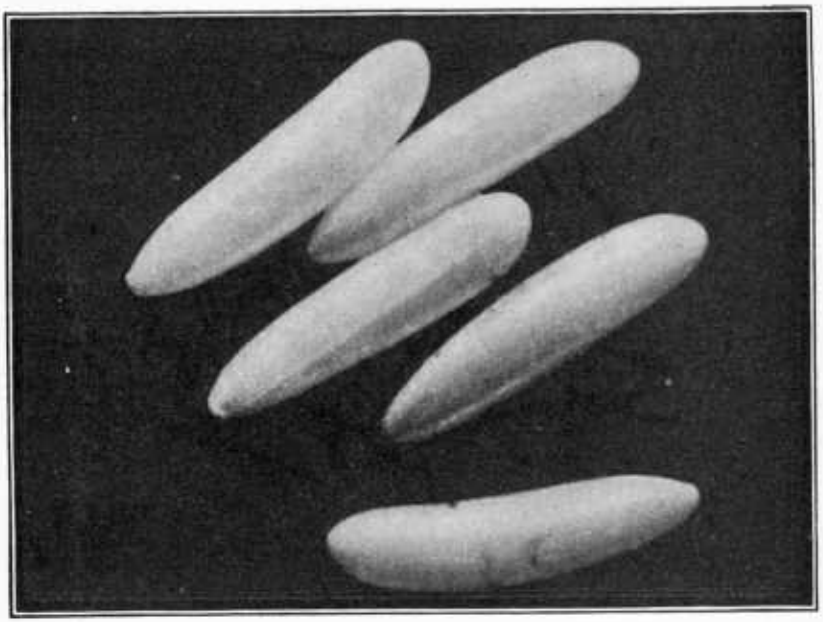

FIG. 10.—Eggs of the house fly. Highly magnified. (From Newstead.)

during hibernation for as long as four or five months. Numerous rearing experiments in various parts of the country have shown that the shortest time between the deposition of eggs and the emergence of the adult fly is eight days, and 10 and 12 day records were very common.

The adult fly, upon emerging from the puparium, works its way upward through the soil or manure and upon reaching the air it crawls about while its wings expand and the body hardens and assumes its normal coloration. In a very few days the female is ready to deposit eggs. In recent experiments at Dallas, Tex., at New Orleans, La., and at Arlington, Va., it has been found that the

time between the emergence of the adults and the first deposition of eggs is considerably shorter than was previously thought to be the case. Only three or four days are necessary in midsummer for the female to reach sexual maturity. As in the case of other periods of its life history, so the preoviposition period is considerably prolonged by the lower temperatures of spring and autumn. In midsummer, with a developmental period of from eight to ten days from egg to adult, and a preoviposition period of from three to four days, there would be a new generation started every 11 to 14 days. There is thus abundance of time in the climate of Washington for the development of 10 to 12 generations every summer.

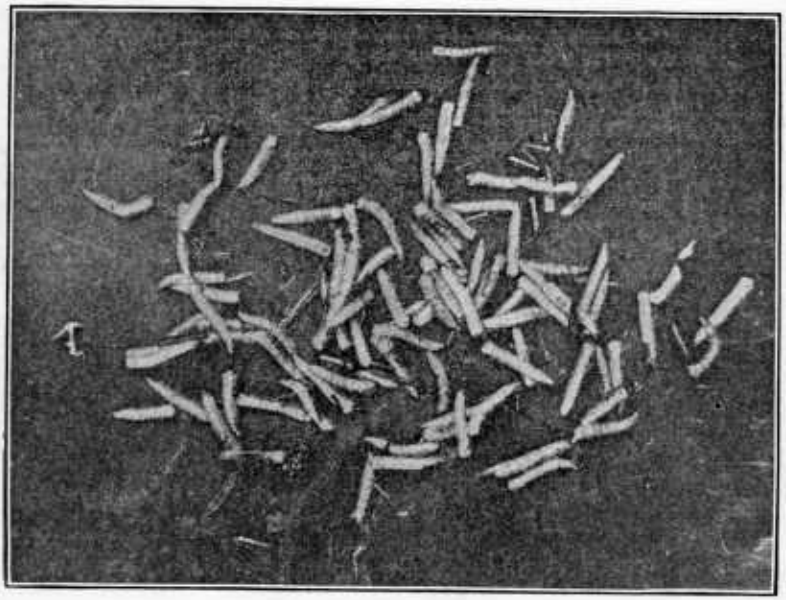

FIG. 11.—Larvæ, or maggots, of the house fly. About natural size. (From Newstead.)

The hibernation of the house fly is a subject to which considerable attention has recently been given, and many new points of practical importance have come to light. The prevailing idea that the house fly passes the winter as an adult, hiding in the cracks and crevices of buildings and in straw stacks, etc., has never been proved experimentally. Messrs. Bishopp, Dove, and Parman made attempts to keep adults in large cages through the winter of 1913–14 at Dallas, Tex. In one experiment in which the cage was kept in a building which was heated during cold periods some flies remained alive for 53 days. In some experiments carried out by the junior author at New Orleans during the same winter all the flies died within a period of 30 days, most of them as a result of the attack of a parasitic

fungus. Careful experiments conducted at the experiment farm at Arlington, Va., during the winter of 1914–15 showed that flies kept in unheated buildings were killed during the first really cold nights of the winter. Those kept in one of the greenhouses behaved just as they would during the summer at similar temperatures. At temperatures of 65° to 75° F. very few lived longer than 35 to 40 days. The best conditions were found in one of the large stables which was slightly heated, the temperature ranging from 32° to 50° F. Some

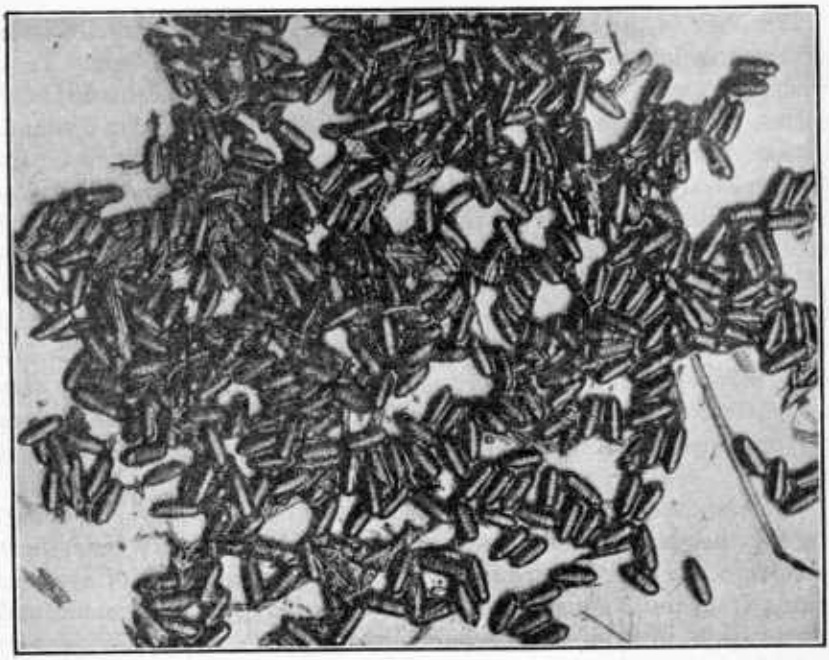

FIG. 12.—Pupæ of the house fly. About natural size. (From Newstead.)

flies were kept alive here for a period of 70 days, a long period, but not sufficient to carry them through the winter.

Regular collections of flies were made at the Arlington farm during the winter of 1914–15. No living adult house flies were found after the middle of January until April 30, while Pollenia, which does hibernate in the adult state, could be found in buildings almost any time during the winter, and on warm days they were found outside.

On the other hand, there are on record some experiments and observations which indicate that the usual manner in which the house fly passes the winter is in the pupal stage. Bishopp, Dove, and Parman succeeded in two instances in keeping the species through the winter in the larval and pupal stages. Three barrels of heavily in-

fested manure were covered with a large screen cage on November 26, 1913. No adults emerged after December 27 until April 16, 1914, and others on May 26, at which time observations were discontinued. This showed that the house fly lived in the larval and pupal stages for periods of from five to six months. In another case they were kept alive in the immature stages from December 16, 1913, to April 4, 1914. This was at Dallas, Tex.

CARRIAGE OF DISEASE.

The body of the house fly is thickly covered with hairs and bristles of varying lengths, and this is especially true of the legs. Thus, when it crawls over infected material it readily becomes loaded with germs, and subsequent visits to human foods result in their contamination. Even more dangerous than the transference of germs on the legs and body of the fly is the fact that bacteria are found in greater numbers and live longer in the alimentary canal. These germs are voided, not only in the excrement of the fly, but also in small droplets of regurgitated matter which have been called "vomit spots." When we realize that flies frequent and feed upon the most filthy substances (it may be the excreta of typhoid or dysentery patients or the discharges of one suffering from tuberculosis), and that they may subsequently contaminate human foods with their feet or their excreta or vomit spots, the necessity and importance of house-fly control is clear.

In army camps, in mining camps, and in great public works, bringing together large numbers of men for a longer or shorter time, there is seldom the proper care of excreta, and the carriage of typhoid germs from the latrines and privies to food by flies is common and often results in epidemics of typhoid fever.

And such carriage of typhoid is by no means confined to great temporary camps. In farmhouses in small communities, and even in badly cared for portions of large cities, typhoid germs are carried from excrement to food by flies, and the proper supervision and treatment of the breeding places of the house fly become most important elements in the prevention of typhoid.

In the same way other intestinal germ diseases are carried by flies. Asiatic cholera, dysentery, and infantile diarrhea are all so carried. Nor are the disease-bearing possibilities of the house fly limited to intestinal germ diseases. There is strong circumstantial evidence that tuberculosis, anthrax, yaws, ophthalmia, smallpox, tropical sore, and parasitic worms may be and are so carried. Actual laboratory proof exists in the case of a number of these diseases, and where lacking is replaced by circumstantial evidence amounting almost to certainty.

NATURAL ENEMIES.

The house fly has a number of natural enemies. The common house centipede (fig. 13) destroys it in considerable numbers; there is a small reddish mite which frequently covers its body and gradually destroys it; it is subject to the attacks of hymenopterous parasites in its larval and pupal condition; and it is destroyed by predatory beetles at the same time.

The most effective enemy of the house fly, however, is a fungous disease known as *Empusa muscae*, which carries off flies in large numbers, particularly toward the close of the season. The epidemic ceases in December, and, although many thousands are killed by it, the remarkable rapidity of development in the early summer months soon more than replaces the numbers thus destroyed.

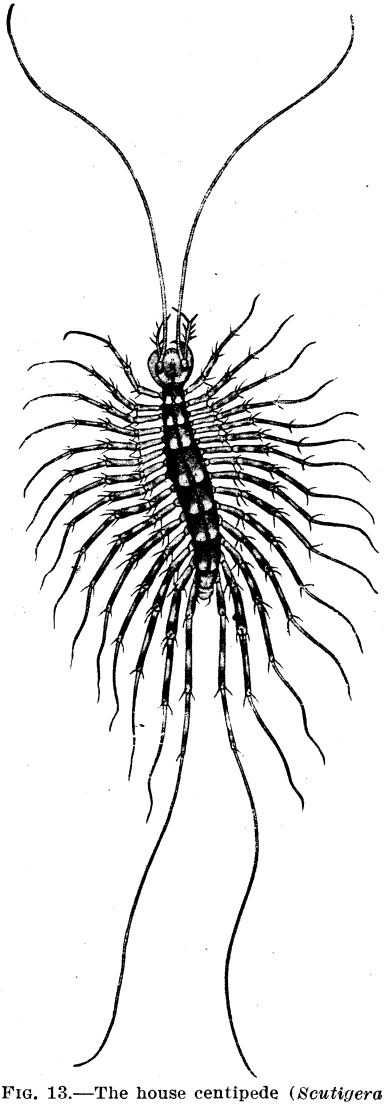

FIG. 13.—The house centipede (*Scutigera forceps*): Adult, natural size. (After Marlatt.)

PREVENTIVE AND CONTROL MEASURES.

THE USE OF SCREENS.

A careful screening of windows and doors during the summer months, with the supplementary use of sticky fly papers, is a preventive measure against house flies known to everyone. As regards screening it is only necessary here to emphasize the importance of keeping food supplies screened or otherwise covered so that flies can gain no access to them. This applies not only to homes, but also to stores, restaurants, milk shops, and the like. Screening will, of course, have no effect in decreasing the number of flies, but at least it has the virtue of lessening the danger of contamination of food.

FLY PAPERS, POISONS, AND TRAPS.

In the effort to destroy flies that have gained access to houses the use of sticky fly papers is very common. Another way is to expose in shallow dishes a mixture of formalin and milk or water, sweetened with a little sugar (1 teaspoonful of commercial formalin to 1 teacupful of water or milk). This is most effective when no other liquids are accessible to the flies. Formalin diluted in this manner is not poisonous to man and will not injure fabrics. In this respect it is much safer than the fly poisons containing arsenic.

Burning of fresh pyrethrum powder is also effective in killing flies in rooms.

Flytraps may be used to advantage in decreasing the number of flies. There are many kinds on the market, and as a rule the larger ones are the more effective. These should be placed on the outside of houses, stores, stables, etc. Bananas, sugar and vinegar, milk, and beer will be found to be attractive baits under most circumstances. The use of flytraps has been enthusiastically advocated by Prof. C. F. Hodge, not only because of the immediate results, but because of the chances that the flies may be caught before they lay their first batch of eggs, and thus the possible number of future generations will be greatly reduced. From what was said above in regard to the preoviposition period it will be apparent that flytraps will be more effective in this respect during the spring and autumn months than during midsummer.

The use of fly papers, poisons, and traps are at best only temporary measures. The most logical method of abating the nuisance is the elimination or treatment of all breeding places. It would appear from what we know of the life history and habits of the common house fly that it is perfectly feasible for cities and towns to reduce the numbers of these annoying and dangerous insects so greatly as to render them of comparatively slight account.

CONSTRUCTION AND CARE OF STABLES.

In formulating rules for the construction and care of stables and the disposal of manure the following points must be taken into consideration. In the first place, the ground of soil-floor stables may offer a suitable place for the development of fly larvæ. The larvæ will migrate from the manure to the soil and continue their growth in the moist ground. This takes place to some extent even when the manure is removed from the stables every day. Even wooden floors are not entirely satisfactory unless they are perfectly water-tight, since larvæ will crawl through the cracks and continue their development in the moist ground below. Water-tight floors of concrete or masonry are therefore desirable.

Flies have been found to breed in surprising numbers in small accumulations of material in the corners of feed troughs and mangers, and it is important that such places be kept clean.

FLY-TIGHT MANURE PITS OR BINS.

The Bureau of Entomology has for some years advised that manure from horse stables be kept in fly-tight pits or bins. Such pits can be built in or attached to the stable so that manure can be easily thrown in at the time of cleaning and so constructed that the manure can be readily removed. The essential point is that flies be prevented from reaching the manure, and for this reason the pit or bin must be tightly constructed and the lid kept closed except when the manure is being thrown in or removed. There is no doubt as to the effectiveness of this method when the necessary precautions are taken, especially if the manure is removed at frequent intervals.

FREQUENCY WITH WHICH MANURE SHOULD BE REMOVED.

Another point must be considered in deciding the question as to how often the manure should be removed. In this connection it should be borne in mind that when the larvæ have finished feeding, they will often leave the manure and pupate in the ground below or crawl some distance away to pupate in débris under boards or stones and the like. Hence the manure should be removed before the larvæ reach the migratory stage; that is to say, removal is necessary every three days, and certainly not less frequently than twice per week during the summer months. A series of orders issued in 1906 by the Health Department of the District of Columbia, on the authority of the Commissioners of the District, covers most of these points, and these orders, which may well serve as a model to other communities desiring to undertake similar measures, may be briefly condensed as follows:

HEALTH OFFICE REGULATIONS FOR CONTROL OF HOUSE FLIES IN CITIES.

All stalls in which animals are kept shall have the surface of the ground covered with a water-tight floor. Every person occupying a building where domestic animals are kept shall maintain in connection therewith a bin or pit for the reception of manure and, pending the removal from the premises of the manure from the animal or animals, shall place such manure in said bin or pit. This bin shall be so constructed as to exclude rain water and shall in all other respects be water-tight, except as it may be connected with the public sewer. It shall be provided with a suitable cover and constructed so as to prevent the ingress and egress of flies. No person owning a stable shall keep any manure or permit any manure to be kept in or upon any portion of the premises other than the bin

or pit described, nor shall he allow any such bin or pit to be overfilled or needlessly uncovered. Horse manure may be kept tightly rammed into well-covered barrels for the purpose of removal in such barrels. Every person keeping manure in the more densely populated parts of the District shall cause all such manure to be removed from the premises at least twice every week between June 1 and October 31, and at least once every week between November 1 and May 31 of the following year. No person shall remove or transport any manure over any public highway in any of the more densely populated parts of the District except in a tight vehicle, which, if not inclosed, must be effectually covered with canvas, so as to prevent the manure from being dropped. No person shall deposit manure removed from the bins or pits within any of the more densely populated parts of the District without a permit from the health officer. Any person violating any of the provisions shall, upon conviction thereof, be punished by a fine of not more than $40 for each offense.

Not only must horse stables be cared for, but chicken yards, piggeries, and garbage receptacles as well. In cities, with better methods of disposal of garbage and with the lessening of the number of horses and horse stables consequent upon electric street railways, bicycles, and automobiles, the time may come, and before very long, when window screens may be discarded.

DISPOSAL OF MANURE IN RURAL AND SUBURBAN DISTRICTS.

The control of flies in rural and suburban districts offers a much more difficult problem. Here it is out of the question to remove all manure from the premises twice a week. The problem is rather to find some method of disposal or storage which will conserve the fertilizing value of the manure and at the same time prevent all flies from breeding or destroy such as do breed there.

With this idea in mind it has been recommended that stable manure be removed every morning and hauled out at once and spread rather thinly on the fields. This procedure is advisable from the point of view of getting the maximum fertilizing value from the manure. Immediate spreading on the fields is said largely to prevent the loss of plant food which occurs when manure is allowed to stand in heaps for a long time. This method will be effective in preventing the breeding of flies only if the manure is hauled out promptly every morning and spread thinly so that it will dry, since it is unfavorable for fly development in dessicated condition. Removal every three or four days will not be sufficient. Observations have shown that if manure becomes flyblown, and the maggots attain a fairly good size before the manure is scattered on the fields, they can continue their

development and will pupate in the ground. A further objection is that during the summer months, when fly breeding is going on most actively, the agriculturist is also busy and can seldom spare the time or the teams to carry out such a program regularly.

CHEMICAL TREATMENT OF MANURE TO DESTROY FLY MAGGOTS.

The general practice is, therefore, to remove manure and keep it in heaps located as a rule very near the stables. How can fly breeding be prevented in such accumulations? As a result of recent investigations it is now possible to point out two methods which are practical and effective.

The first is the treatment of the manure pile with chemical substances which will kill the eggs and maggots of the house fly. The Bureau of Entomology, in cooperation with the Bureau of Chemistry and the Bureau of Plant Industry, has conducted a series of experiments during the last two years in which a large number of chemicals were applied to infested manure and observations made not only on their efficiency in killing the maggots, but also as to their effect on the chemical composition and bacterial flora of the manure. The object was to find some cheap chemical which would be effective in destroying the fly larvæ and at the same time would not reduce the fertilizing value of the manure.

TREATMENT WITH HELLEBORE.

Of the numerous substances tried, the one which seems best to fulfill these conditions is powdered hellebore. Some of the powdered hellebore in use is prepared from the roots of a plant which botanists know as *Veratrum viride*, and which is popularly known as Indian polk or itch weed. It is common in wet grounds and is of wide distribution in the United States. The European species of this plant, *Veratrum album*, however, furnishes the bulk of the supply. Hellebore contains a number of chemical compounds known as alkaloids. Alkaloids are organic substances, of which quinine, morphine, and cocaine may be mentioned as examples, which act very intensely on the animal body. For the treatment of manure a water extract of the hellebore is prepared by adding ½ pound of the powder to every 10 gallons of water, and after stirring it is allowed to stand 24 hours. The stock mixture thus prepared is sprinkled over the manure at the rate of 10 gallons to every 8 bushels (10 cubic feet) of manure. From the result of 12 experiments with manure piles treated under natural conditions it appears that such treatment results in the destruction of from 88 to 99 per cent of the fly larvæ. Amounts of hellebore less than ½ pound to every 8 bushels of manure are not so effective, while stronger applications will, of course, give somewhat better results.

Bacteriological studies of the treated piles proved that the bacteria were not injured nor their development retarded, and chemical analysis showed that the composition of the manure was unaltered. Furthermore, several field tests were made in growing cabbages, turnips, lettuce, potatoes, wheat, and a few other crops on plats which had been fertilized with hellebore-treated manure, with the result that there appeared no injury whatever that could be ascribed to the use of this substance. The only possible objection to the use of hellebore seems to be the possibility of poisoning farm animals, as might happen if, for example, the barrel or tank in which the stock solution was prepared were left uncovered in an accessible place. It is quite safe to say that chickens will not be injured by pecking at hellebore-treated manure. This has been tested carefully. Hellebore can be obtained both in ground and powdered form, but the powdered form gives the best results in the destruction of fly larvæ. It costs from 12 to 16 cents per pound and under normal conditions can be obtained in large lots for 10 cents or less per pound. It is estimated that the cost of treating horse manure with hellebore will be a little over 1 cent for every 2 bushels. It will be of interest to the agriculturist to know that in applying hellebore to manure he is adding a substance which contains fully 1 per cent of nitrogen.

TREATMENT WITH POWDERED BORAX.

Another chemical found to be even more effective as a larvicide is powdered borax. This is an inorganic substance, available in commercial form in all parts of the country. It has the advantage of being comparatively nontoxic and noninflammable and is easily transported and handled. The minimum amount necessary to kill fly larvæ was found to be 0.62 pound per 8 bushels of manure, or about 1 pound per 16 cubic feet. Best results were obtained when the borax was applied in solution, or when water was sprinkled on after the borax had been scattered evenly over the pile. Borax is not only effective in killing the larvæ, but when it comes in contact with the eggs it exerts a toxic action which prevents them from hatching. When applied at the rate of 1 pound to 16 cubic feet it was found to kill about 90 per cent of the larvæ, heavier applications killing from 98 to 99 per cent.

Borax had no injurious effect on the composition of the manure; in fact, in some cases the ammonia and water-soluble nitrogen seemed to be increased; nor was there any permanent decrease in the number of bacteria. Borax-treated manure was less subject to the growth of molds and consequent firefanging. Now, although borax does not have any deleterious effect on the chemical composition of manure, yet when added to the soil with the manure it acts directly on plants,

and large applications will cause considerable injury. On the other hand, certain investigators have shown that small amounts of borax have a stimulating effect. The question is, therefore, whether any injury to plants will result from the application of manure treated at the rate of 1 pound per 16 cubic feet. To answer this point numerous tests were carried out, both in the greenhouse and under field conditions, using borax-treated manure for fertilizing a number of different crops, such as wheat, potatoes, peas, beans, lettuce, and others. As far as these experiments have gone they indicate that if manure so treated is applied at a rate of not more than 15 tons per acre no injury, as a rule, will follow. However, some plants are more sensitive to the presence of borax than others, and the effects are more noticeable on some soils than on others. All crops have not been tested, nor has the cumulative effect of borax treatment been worked out. It is necessary, therefore, to repeat the warning issued in connection with a previous bulletin on this subject, that great care should be exercised in the application of borax, so that the manure will never receive more than 1 pound for every 16 cubic feet and that not more than 15 tons of manure so treated should be applied to the acre.

THE BEST SUBSTANCE FOR TREATMENT OF MANURE INTENDED FOR USE AS A FERTILIZER.

In view of the possible injury from the borax treatment as a result of carelessness in applying it, or from other unforeseen conditions, it is to be recommended that horse manure and other farmyard manures which are to be used as fertilizer should be treated with hellebore. Borax, on the other hand, is such a good larvicide that it can be used with advantage on the ground of soil-floor stables, in privies, on refuse piles, and on any accumulations of fermenting organic matter which are not to be used for fertilizing purposes.

Of course there are a number of other insecticides which are effective against fly larvæ. Potassium cyanid, Paris green, arsenite of soda, etc., are effective, but they are hardly to be recommended for general use because of their extremely poisonous nature. Others, like pyridine, aniline, and nitrobenzene emulsion, are rather too expensive when used in amounts necessary to kill the maggots.

MAGGOT TRAP FOR DESTRUCTION OF FLY LARVÆ FROM HORSE MANURE.

The second method of handling manure is one which does not require the application of chemicals. It is based on the fact mentioned on page 7 that the larvæ of the house fly, when about ready to pupate, show a very strong tendency to migrate. They leave the spot where they have been feeding and crawl about in search of a suitable

place for pupation. This migration takes place mostly at night, and the larvæ sometimes crawl considerable distances away from the manure pile. Now it is possible by means of a very simple arrangement called a maggot trap to destroy fully 99 per cent of all maggots breeding in a given lot of manure. A successful maggot trap which the Maryland Agricultural College constructed at the college barn last year is shown in figure 14. The trap was designed by the junior author and constructed under his supervision. The manure, instead of being thrown on the ground, is heaped carefully on a slatted platform, which stands about 1 foot high. This particular platform meas-

FIG. 14.—A maggot trap for house-fly control. View of the maggot trap, showing the concrete basin containing water in which larvæ are drowned, and the wooden platform on which manure is heaped. (From Hutchison.)

ures 10 by 20 feet. There are six 2 by 4 pieces running lengthwise 2 feet apart. Across these are nailed 1-inch strips with $\frac{1}{2}$ to 1 inch spaces between them. The wooden platform stands on a concrete floor, and a rim or wall of concrete 4 inches high surrounds the floor. The floor slopes a little toward one corner, from which a pipe leads to a small cistern near by. This pipe is plugged with a stopper of soft wood, and the concrete floor is filled with water to a depth of 1 inch in the shallowest part. The manure is then heaped on the platform each morning when it is removed from the stable. Flies will lay their eggs on the manure as usual, but the maggots, when they have finished feeding and begin to migrate, crawl out of the

manure, drop into the water below, and are drowned. Each week the plug is removed from the pipe, and all the maggots are washed into the cistern. The floor is then cleaned of any solid particles by means of a long-handled stable broom or by a strong stream of water from a hose. The pipe being again plugged, the floor is again partly filled with water and the trap is ready for another week's catch. A platform of this size will hold the manure accumulating from four horses during the period of four months, or about 20 days' accumulation from 25 horses, if the heap is well built and made at least 5 feet high.

Experience with maggot traps has brought out the following points: In the first place, the trap is more effective when the manure is kept compactly heaped and well moist. This is to be explained by the fact that the larvæ seek a comparatively dry place in which to

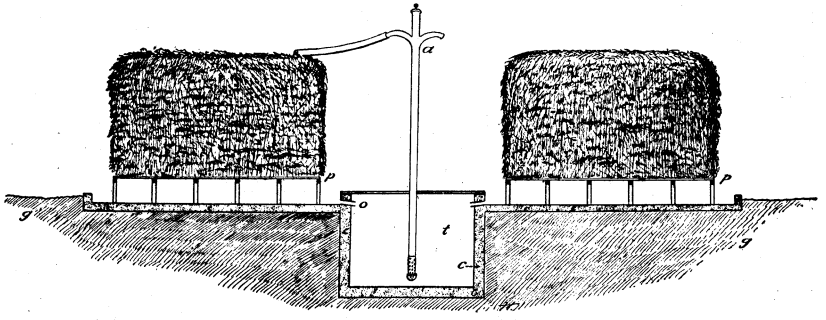

FIG. 15.—Imaginary cross section of an arrangement suggested for use where manure production is large. *a*, Pump; *c*, concrete floor and walls of cistern; *o*, outlet pipes leading from floor of maggot trap to cistern; *p*, platform maggot trap; *t*, cistern for liquid manure; *g*, ground level. (From Hutchison.)

pupate, and crawl away from wet manure. A cistern should be built close to the trap, and a pump fitted so that liquids can be pumped onto the heap. (Fig. 15.) Each day, after the litter from the stable has been thrown on the heap, just enough water should be added to moisten it thoroughly without causing leaching. The ideal arrangement would be to have water-tight floors in the stalls and drains leading to the cistern. The liquid manure collecting in the cistern could be pumped on the manure heap, thus not only maintaining the moisture content necessary to insure the greatest amount of migration, but also adding to the manure the valuable constituents of the urine. It happens, too, that keeping the manure carefully heaped and watered promotes the anaerobic fermentation and tends to prevent to some degree the loss of ammonia and gaseous nitrogen.

In the second place the platform should stand not less than 1 foot above the concrete floor. This is to facilitate cleaning the floor of maggots and the débris which unavoidably accumulates there. The

floor should be cleaned at least once a week, and all liquids run into the cistern, in order to prevent mosquitoes from breeding in the water in the floor of the trap. A thin film of oil can be used to prevent mosquito breeding in the cistern.

A third point of importance is that old manure is unfavorable for fly breeding. Experiments have shown that after manure has been standing on a maggot trap for eight to ten days it is practically free from maggots, and no more will appear in it. This means that a given lot of manure need remain on the maggot trap for only 10 days in order to prevent any breeding taking place in it.

The maggot trap is simple, easily constructed, and cheap. Practically the only cost is the initial one for the construction. Very little extra labor is required to operate it. Only a few minutes each day are necessary to water the manure after the stable cleanings have been added to the heap. Cleaning the floor to dispose of the maggots and to prevent mosquito breeding will take about half an hour once a week.

That the maggot trap is effective has been shown by the junior author's observations at the Maryland Agricultural College. It was found that the trap destroyed 99 per cent of the larvæ breeding there and that the number of flies at the barn and around the college kitchen was reduced from 67 to 76 per cent. That the reduction in the prevalence of flies was not equal to the percentage of larvæ destroyed was ascribed to the fact that several other piles of untreated manure were breeding out flies at near-by stables, from which places they were attracted to the barn and kitchen.

Maggot traps may be constructed in almost any size and to suit almost any conditions, and appear to be especially adapted to meet the problem of fly control under rural conditions.

TREATMENT OF MISCELLANEOUS BREEDING PLACES.

It is just as true under farm conditions as in cities that breeding places other than horse manure must be attended to. Garbage must be disposed of, hog and poultry manure must be cared for, and especially on dairy farms it is extremely important that every precaution be taken to prevent the contamination of milk by flies. Care and cleanliness, combined with some of the arrangements just described, will measureably affect the fly nuisance in neighboring buildings.

SEWAGE DISPOSAL IN RELATION TO THE PREVENTION OF FLY-BORNE DISEASES.

In the consideration of these measures we have not touched upon the remedies for house flies breeding in human excrement. On account of the danger of the carriage of typhoid fever, the dropping of human excrement in the open in cities or towns, either in vacant

lots or in dark alleyways, should be made a misdemeanor, and the same care should be taken by the sanitary authorities to remove or cover up such depositions as is taken in the removal of the bodies of dead animals. For modern methods of sewage disposal adapted for farm use one should consult Department Bulletin No. 57, which may be obtained from the Superintendent of Documents for 10 cents. In the absence of modern methods of sewage disposal absolutely sanitary privies are prime necessities, whether in towns or on farms. Directions for the building and caring for such privies will be found in Farmers' Bulletin No. 463. The box privy is always a nuisance from many points of view, and is undoubtedly dangerous as a breeder of flies which may carry the germs of intestinal diseases. The dry-earth treatment of privies is unsatisfactory. No box privy should be permitted to exist unless it is thoroughly and regularly treated with some effective larvicide. Since the fecal matter in such privies is seldom used for fertilizing purposes it may well be treated liberally with borax. The powdered borax may be scattered over the exposed surface so as to whiten it. An application two or three times a week during the fly season ought to prevent all fly breeding in such matter.

WHAT COMMUNITIES CAN DO TO ELIMINATE HOUSE FLIES.

Antifly crusades have been very numerous in recent years, and some have been noteworthy both as to methods and results. However, it will not be amiss here to emphasize the importance of concerted, organized effort on the part of whole communities, not only cities, but suburban and rural neighborhoods as well. By the most painstaking care one may prevent all fly breeding on his premises, but it will avail him little if his neighbors are not equally careful. Some sort of cooperation is necessary. One of the first and most important elements in any antifly crusade is a vigorous and continued educational campaign. It has been the experience of those who have undertaken such crusades that people generally regard the fly as a somewhat harmless nuisance and that the first work of the campaign was to bring the people to a realization of the dangers from flies and the possibility of getting rid of them. In the educational campaign every possible means of publicity can be employed, including newspapers, lectures, moving pictures, posters, handbills, cartoons, instruction in schools, etc.

The antifly crusade is a matter of public interest and should be supported by the community as a whole and engineered by the health officers. But health officers can do little toward the necessary work of inspection and elimination without funds, and therefore the support of the campaign must manifest itself in increased appropriations

for public-health work. The example of York Village, Me., is one to be emulated. The appropriation for health work in that city amounts to about $1 per capita per year—the largest per capita expenditure for public-health work of any community in the United States. Very often it is lack of funds which prevents the health officers from taking the initiative in the antifly crusades, and there must necessarily be much agitation and education before they can profitably take up the work. Right here lies a field for civic associations, women's clubs, boards of trade, etc., to exercise their best energy, initiative, and leadership.

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